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CHARACTERISTICS AND HYBRIDIZATION OF IMPORTANT INTERMOUNTAIN SHRUBS. II. CHENOPOD FAMILY

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ABSTRACT

Chenopod shrubs as a group constitute a significant segment of the Intermountain area's vast shrub lands. In alkaline areas, they are the principal component of the vegetation. They are producers of forage, they provide cover and, most importantly, they stabilize xeric, mineral soils where few other plants are adapted. General characteristics--vegetative, floral, reproductive, hybridization, distribution and habitat, and use--are described and reviewed for Atriplex canescens, A. confertifolia, A. corrugata, A. cuneata, A. gardneri, A. obovata, Ceratoides lanata, Grayia brandegei, G. spinosa, Kochia americana subsp. vestita, K. prostrata, and Sarcobatus vermiculatus. Artificial hybridization studies indicate considerable interspecific gene exchange and at least some intergeneric hybridization are possible. A taxonomic key covering each taxon discussed is provided.

INTRODUCTION

Shrubby chenopods, commonly referred to as saltbushes, cover millions of hectares on the world's alkaline ranges. They are important on the arid deserts of northern America, interior Australia, Africa, and Eurasia. These shrubs are of special significance in the Great Basin and Colorado River Drainage where as a group they are often the dominant vegetation below 1,677 meters (5,500 feet) (Branson 1966).

On ranges where they occur, they are important producers of nutritious forage for game and domestic animals. More importantly, their presence is essential for maintaining a stable soil in highly xeric environments where the soil is too salty and dry for most other classes of plants to live (Gates and others 1956). This group of shrubs grows well in high concentrations of calcium and potassium salts, and can endure considerable sodium; some require it (Gates and others 1956; McNulty 1969; Moore and others 1972). Consequently, we must especially look to shrubby chenopods for stabilization of arid and alkaline soils disturbed by oil drilling, mining operations, and road and building construction, as well as for improving vast areas of arid ranges. Most shrubby chenopods supply adequate nutrition that adds greatly to their value in providing habitat for a multitude of animals, including domestic ones (Esplin and others 1937; Cook and others 1951; Cook 1972). Chenopods can provide the shrubby components that along with grasses and forbs give a balanced cover and diet (Plummer and others 1968).

Shrubby chenopods from different localities and sometimes from the same site vary considerably in palatability, growth rate, forage production, and other characteristics that make them important sources of browse and cover. Some should have an important place in stabilization of disturbed areas on alkaline ranges. Natural hybridization has been observed between species of the same genus and even between different genera.

The purpose of this paper is to document what is known about important chenopod shrubs in the Intermountain area, with regard to their vegetative and floral characteristics, hybridization, distribution and habitat, and use. Most of the observational information and experimental data were gathered from the Intermountain area (Holmgren and Reveal 1966), particularly from Utah. Holmgren and Reveal's Intermountain area "includes all of Utah, that portion of Arizona north of the Grand Canyon, most of Nevada, parts of California that lie within the Great Basin, the sagebrush areas of southeastern Oregon, southern Idaho to the high mountainous areas to the north, and the Red Desert area of southwestern Wyoming." However, reference to and comments on species distribution and characteristics outside this area are made when pertinent. This is done to provide a basis for extended use and improvement of this group by selection and hybridization. Since Utah is centrally located in the distribution of this family, observations are fairly characteristic of west-central North America.

Each species, its hybridization, distribution and habitat, and use are described in detail. Each genus and its included species are arranged in alphabetical order. A key (appendix) is given for the included genera and species. This paper is the second in a series on Intermountain shrub species; the first is Blauer and others (1975).

METHODS

A survey of literature, particularly of pertinent keys and monographs, was made ahead of intensive selection and breeding trials. In addition, field observations were made during the 1967 and subsequent growing seasons on floral and vegetative characteristics of the shrubs. Collections were made of most species in various stages of development for illustrative purposes. Where no data were available on the number of seeds per pound, the number was determined on the basis of 10 samples of 100 seeds each.

Artificial hybridization was attempted by treating pistillate bushes of *Atriplex canescens* with pollen from various species of *Atriplex*, *Grayia*, *Ceratoides lanata*, and *Sarcobatus vermiculatus* (fig. 1). These crosses were made to determine any major difficulties in interspecific hybridization within and between these closely related genera. Information regarding these crosses is presented in the following resumes for the species with which hybridization was performed.

Germination tests were conducted to determine viability of the seed produced from the crosses. For these tests, the seeds were placed on moistened newspapers or paper towels, which were then folded in half (fig. 2). The folded papers were covered by plastic sheets and placed in refrigerators maintained at temperatures between 1° and 3° C. Seeds that sprouted were transplanted to pint milk cartons and placed in greenhouses to develop (fig. 3).

Seedlings obtained from various crosses since 1968 were transplanted during the latter part of May 1971 at the Snow Field Station north of Ephraim, Utah.

Figure 1.--Pistillate fourwing saltbush (Atriplex canescens) *with bagged branches treated with pollen from different species of* Atriplex. *The same procedure was used when treating fourwing saltbush with pollen from* Grayia, Ceratoides, *and* Sarcobatus.

Figure 2.--Sprouted fourwing saltbush seed on moist paper towels.

Figure 3.--Putative artificial fourwing saltbush hybrid seedlings.

SPECIES CHARACTERISTICS

Atriplex—Common Floral Characteristics

The *Atriplex* species discussed in this paper are largely dioecious, although monoecious plants are found in most populations.

The staminate flowers lack petals and bracts. They normally have five united sepals and five stamens borne opposite the calyx lobes (fig. 4 and 5). These male flowers are borne in small compact clusters called glomerules.

Figure 4.--Fourwing saltbush staminate flower in late bud. The calyx lobes have separated and exposed the anthers (X20).

Figure 5.--Fourwing saltbush staminate flower in late anthesis. The filaments have elongated and the anthers have dehisced (X20).

The pistillate flowers lack both sepals and petals (fig. 6). They consist only of pistils, each subtended by two bracts, which enlarge and enclose the fruit as it matures. The margins and surfaces of the bracts are highly variable among the different *Atriplex* species (fig. 7).

Figure 6.--A single pistillate flower of fourwing saltbush. Note the swollen ovary and the two slender styles (X20).

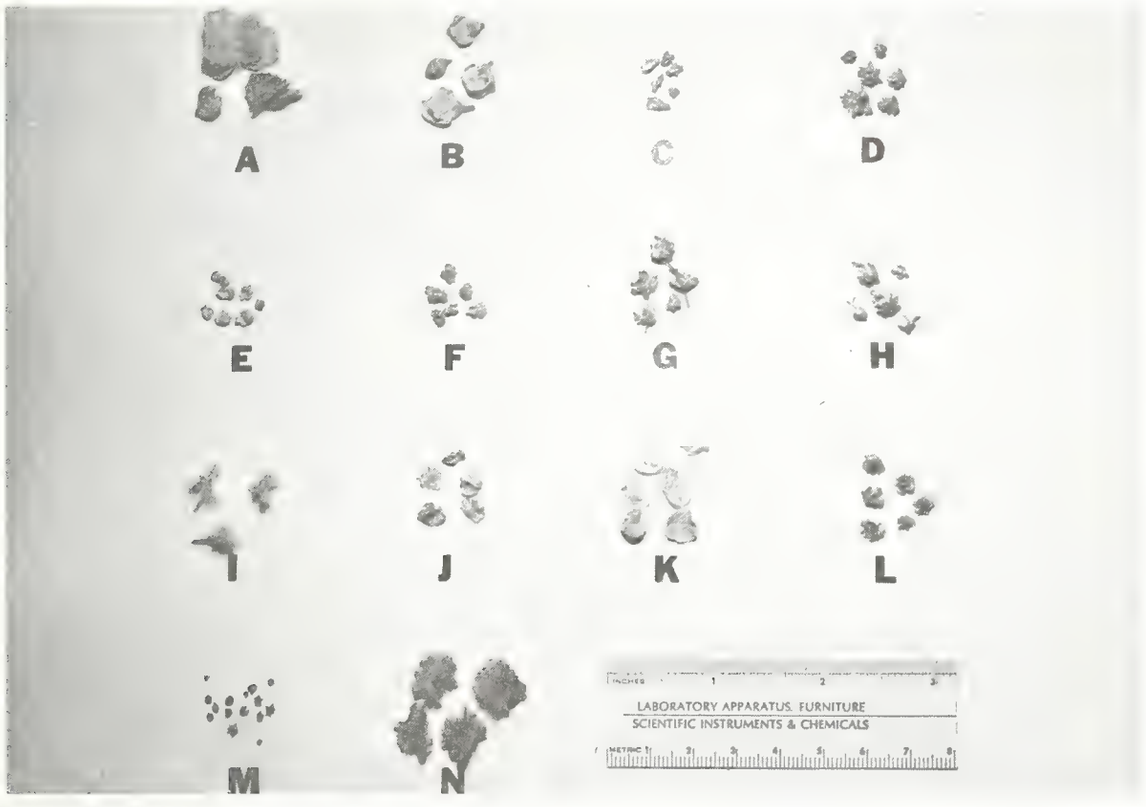

Figure 7.--Comparison of typical chenopod utricles. Note bract variation. (a) Atriplex canescens, *(b)* A. confertifolia, *(c)* A. corrugata, *(d)* A. cuneata, *(e)* A. gardneri, *(f)* A. obovata, *(g)* A. canescens × A. confertifolia, *(h)* A. canescens × A. gardneri, *(i)* Ceratoides lanata, *(j)* Grayia brandegei, *(k)* G. spinosa, *(l)* Kochia americana vestita, *(m)* K. prostrata, *(n)* Sarcobatus vermiculatus.

Atriplex canescens (fourwing saltbush)

Fourwing saltbush is a shrub usually from 0.5 to 2.0 meters tall (fig. 8). It branches freely from the base, and the branches are usually quite brittle. Both the young twigs and the leaves are gray green because of the white, scurfy vestiture. The linear to oblanceolate or spatulate evergreen leaves are 1 to 4 cm long and 2 to 6 mm wide.

In fourwing saltbush populations he sampled, Hanson (1962) noted that as high as 3 percent of the plants were monoecious; however, we have observed populations in which the number of monoecious plants reached as high as 14 percent. A few populations may have no monoecious plants. Pistillate flowers are small and inconspicuous with no flower parts except pistils. Each pistil is enclosed by a pair of small bracts that are united along their edges to form winglike expansions. In addition, each bract of the pair has a wing down its middle; so the fruit (utricle) at maturity has a varying prominence of four wings (fig. 9). There is a high degree of variation in this characteristic, since some utricles are practically wingless. The yellow to red to brown male flowers are borne in glomerules 2 to 3 mm wide.

Fourwing saltbush blooms from May to July in the Upper Sonoran zone. In the Lower Sonoran zone, blooming occurs from July to August. Increase in elevation within zones delays flower development.

Utricles mature 14 to 16 weeks after flowering. They are usually persistent and can be harvested from mid-October through April (Benson and Darrow 1944; Plummer and others 1966a). Occasionally, utricles from the past two seasons can be found on bushes growing on drier sites. Dewinged utricles of this shrub average 55,365 per pound (122/g) (Plummer and others 1968). The utricle wings are removed by hammer milling and fanning.

Figure 8.--Pistillate fourwing saltbush showing highly branched habit and heavy utricle production.

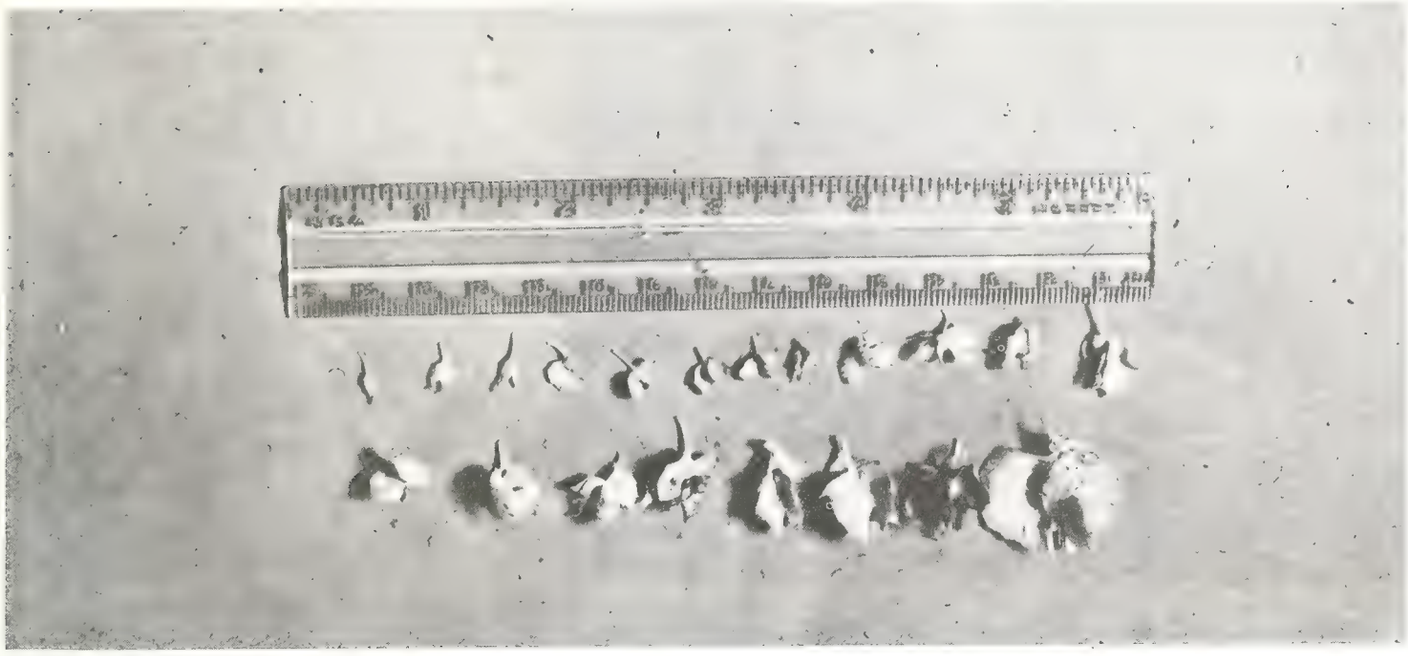

Figure 9.--Fourwing saltbush utricle variation in half-sib family growing at Snow Field Station, Ephraim, Sanpete County, Utah.

Garrett saltbush (*Atriplex garrettii*), a form closely related to fourwing saltbush, also has four-winged utricles. It differs by being a subshrub under 40 cm tall with wider leaves, oval or broadly elliptical in shape.

The taxonomic status of Garrett saltbush is uncertain. Some authors (Hall and Clements 1923; Harrington 1954; Brown 1956) consider it a subspecies of fourwing saltbush. Other authors (Kearney and Peebles 1960; Hanson 1962; Plummer and others 1966b) accept it as a separate species. Garrett saltbush is a narrow endemic. It occurs only along the Colorado River and its tributaries in southern Utah and closely adjoining areas.

Hybridization: Fourwing saltbush readily hybridizes in nature with other *Atriplex* species (Hanson 1962; Plummer and others 1957; Plummer and others 1966a; Drobnick and Plummer 1966), (fig. 10 and 11). Our preliminary results and the results of Drobnick and Plummer (1966) indicate that artificial pollination of pistillate fourwing saltbush with pollen from shadscale saltbush (*Atriplex confertifolia*), Gardner saltbush (*A. gardneri*) (fig. 12), mat saltbush (*A. corrugata*), winterfat (*Ceratoides lanata*), black greasewood (*Sarcobatus vermiculatus*), spiny hopsage (*Grayia spinosa*), and spineless hopsage (*G. brandegei*) has resulted in viable seed. It is not known whether this pollination produces genuine hybrid seed in all cases. It may stimulate asexual reproduction in which seeds develop from unfertilized eggs or from somatic cells associated with egg cells.

Table 1 shows percent germination of seed obtained from the various crosses attempted during 1968 and 1969. Several important incidents occurred that reduced production of putative hybrid seed between fourwing saltbush and shadscale saltbush, mat saltbush, and spineless hopsage. During 1967, heavy winds and rain detached many of the sacked branches, and failure to cover the treated branches with cloth sacks prior to seed maturation resulted in losses attributed to rodents, deer, and natural drop. A late spring frost in 1968 killed most of the fruit at several locations. A large number of seedlings were lost in a greenhouse because of excessive heat and dehydration during the winter of 1969-70.

*Figure 10.--From left to right, Castle Valley clover saltbush (*Atriplex cuneata*), Castle Valley clover saltbush × fourwing saltbush hybrid, fourwing saltbush.*

*Figure 11.--Putative hybrid between fourwing saltbush and shadscale saltbush (*Atriplex confertifolia*).*

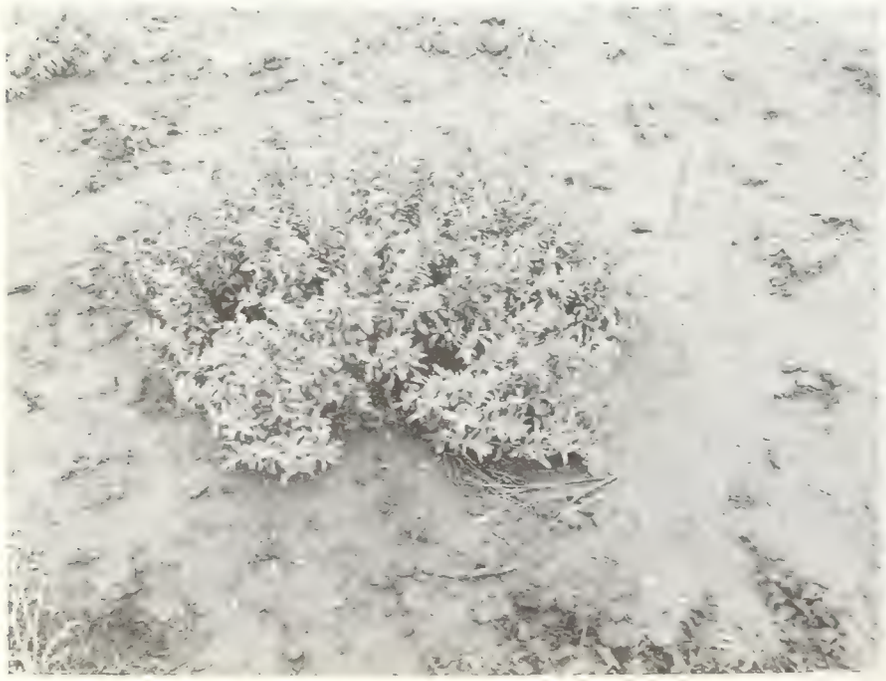

*Figure 12.--Artificial hybrid between fourwing saltbush and Gardner saltbush (*Atriplex gardneri*).*

Table 1.--*Seed and seedlings obtained by artificially pollinating pistillate flowers of fourwing saltbush (Atca)* with pollen from winterfat (Cela), shadscale (Atco), mat saltbush (Atco[2]), black greasewood (Save), Gardner saltbush (Atga), and spineless hopsage (Grbr)*

Maternal (seeds) plants	Paternal (pollen) plants	Total branches treated	Branches bearing viable seed	Seed collected	Seed germinated	Percent germination
Atca	Cela	11	2	24	3	12.5
Atca	Atco	6	2	177	14	7.9
Atca	Atco[2]	6	1	45	3	6.7
Atca	Save	10	1	122	19	15.6
Atca	Atga	12	6	387	45	11.6
Atca	Grbr	8	1	274	95	34.7
Atca	Atca	5	4	434	26	6.0
Atca	Control	12	4	40	16	40.0

*Species symbols from Plummer and others 1966b.

Perhaps the most common natural hybrids involving fourwing saltbush are *A. canescens* × *A. confertifolia* and *A. canescens* × *A. cuneata*. The *A. canescens* × *A. confertifolia* hybrid closely resembles shadscale in general stature and habit. Spines on the hybrid are more slender, weaker, and much more branched than on the associated shadscale plant (fig. 11).

This hybrid is similar to fourwing saltbush in the possession of pedicellate bracts and slender branchlets, but it is intermediate between its parents in fruiting bracts, spines, and foliage. For example, the lower half of the bracts is like fourwing saltbush in the possession of four lateral wings, whereas, the upper portion has an expanded, foliaceous terminal tooth like shadscale (fig. 7). The *A. canescens* × *A. cuneata* combinations are highly variable. Several populations suggest local introgression. Individual plants combine parental characteristics in diverse ways.

Fourwing saltbush has a basic chromosome number of x = 9. Except for the diploid ($2n$ = 18) giant form in the sand dunes of the Little Sahara Recreation Area, Juab County, Utah, this species appears to be uniformly tetraploid ($2n$ = 36) (Stutz and others 1975).

Distribution and habitat: Fourwing saltbush is one of the most widespread and adaptable of western shrubs. It grows in a variety of soil types from the Great Plains to the coast ranges and from Canada to Mexico at elevations from below sea level to about 2,440 meters (8,000 feet). This species is most suited to deep, well-drained mesas, ridges, slopes, sandy soil, sand dunes, and gravelly washes; but, vigorous plants have been found in heavy clays as well (Plummer and others 1966a) (fig. 13). Fourwing saltbush is frequently found intermixed with black greasewood, shadscale saltbush, basin big sagebrush (*Artemisia tridentata* subsp. *tridentata*), and occasionally black sagebrush (*A. nova*). Hanson (1962) noted that it tolerates a maximum soluble salt content of about 1,300 p/m. However, we believe there is considerable variation in salt tolerance among ecotypes of *A. canescens*.

Figure 13.--Fourwing saltbush as dominant vegetation, Desert Range Experiment Station, Millard County, Utah.

Ecotypes of this species exhibit great variation in their natural growth habit. As a result, many subspecies have been unjustifiably proposed. Plummer and others (1966a) have pointed out that a particular form usually is found in a given area, but that large variations may occur from bush to bush. For example, dwarf or short forms less than 1 meter in height are commonly found in desert or highly alkaline areas (fig. 14), whereas, forms that may reach 2 meters are usually observed in the higher foothills of the juniper-pinyon type (fig. 8). In the Little Sahara sand dunes of west-central Utah, a giant form to 4 meters in height occurs (fig. 15). These different ecotypes maintain the basic form of their parent stock when brought together on the same site (Plummer and others 1966a; Stutz and others 1975); so differences are genetically controlled.

Use: Fourwing saltbush is one of the most valuable forage shrubs in arid rangelands because of its abundance, accessibility, palatability, size, evergreen habit, nutritive value, rate of growth, and large volume of foliage. Its leaves, stems, and utricles provide browse in all seasons. In addition to providing forage and cover, this species is one of the most important shrubs for use in rehabilitation of depleted rangelands and in soil stabilization projects in western desert areas (Plummer and others 1968). Fourwing saltbush may be propagated easily by direct seeding, by transplants, and by stem cuttings.

Unfortunately, this species is a secondary or faculative selenium absorber and thus may be mildly poisonous where selenium occurs in the soil (Kingsbury 1964; Davis 1972). Losses have occurred when livestock have little or nothing else to eat (Hitchcock and others 1964).

Sampson and Jespersen (1963) gave fourwing saltbush a browse rating of good to fair for sheep, goats, and deer; and fair to poor for cattle and horses.

Figure 14.--Dwarf form of fourwing saltbush.

Figure 15.--Giant diploid form of fourwing saltbush growing at Little Sahara sand dunes, Juab County, Utah.

*Figure 16.--Pistillate shadscale saltbush (*Atriplex confertifolia*) with abundant utricle production.*

Atriplex confertifolia (shadscale saltbush)

Shadscale saltbush is a compact spinescent shrub growing typically in dense clumps from 2 to 8 dm high and 3 to 17 dm wide (fig. 16). The rigid, brittle branches are scurfy when young, but become smooth and spiny with age.

The leaves are nearly circular to elliptic, oval, or oblong, 9 to 25 mm long, 4 to 20 mm wide. They are gray-scurfy especially at maturity.

Flowers of shadscale are similar to those of fourwing saltbush except in the nature of the bracts enclosing the seed. The bracts of shadscale are foliose, 5 to 12 mm long, broadly oval to almost round, united at the base, and have entire, free, somewhat spreading margins (fig. 7).

Shadscale blooms from late March in the southern portion of its range to mid-June in the northern portion (Hanson 1962). Utricles mature about 15 weeks after blooming. They tend to be fairly persistent through the winter months and are sought out by all grazing animals. Cleaned utricles of this species average 64,920 per pound (142/g) (Plummer and others 1968).

Hybridization: Hanson (1962) stated that shadscale hybridizes with Castle Valley clover saltbush (*Atriplex cuneata*) (fig. 17), fourwing saltbush, Garrett saltbush (*A. garrettii*), mat saltbush (*A. corrugata*), Gardner saltbush (*A. gardneri*), and possibly desertholly saltbush (*A. hymenelytra*). Hanson (1962) further states that natural hybrids with mat saltbush are nearly sterile and those with fourwing saltbush are completely sterile.

Figure 17.--Left to right, shadscale saltbush, shadscale saltbush × Castle Valley clover saltbush hybrid, Castle Valley clover saltbush.

Hanson (1962) found a number of *A. confertifolia* × *A. corrugata* hybrids along roadsides. He examined 420 saltbushes growing along a road at a station near Price, Utah. Of these, 215 (51 percent) were shadscale, 170 (44 percent) were mat saltbush, 28 (7 percent) were cuneate saltbush, and 7 (1.7 percent) were hybrids between shadscale saltbush and mat saltbush. The hybrids grew only a short distance from the pavement and all were under 3 years of age, having grown since road margins were last graded. None of the hybrids were found in adjacent stabilized vegetation. We have observed putative hybrids along Utah Highway 10, south of Emery, Utah.

The shadscale-mat saltbush hybrid is a woody shrub with decumbent to ascending branches. The branches do not root when in contact with the soil; and when mature, they form weak to strong unbranched spines. The bark is gray, soft, and spongy. The pale gray-green, densely scurfy, evergreen leaves measure 7 to 20 mm long, 4 to 9 mm wide, and are oblanceolate to elliptical or spatulate. The fruiting bracts are 8 to 10 mm long and 5 to 8 mm wide with fewer than eight tubercules scattered about the base or with tubercules absent. The bracts are united for about one-half of their length (fig. 7). This hybrid is nearly sterile. Out of 500 large utricles from the Price station, Hanson (1962) found only two with seeds.

Hanson (1962) found a single hybrid of *A. confertifolia* × *A. gardneri* growing intermixed with its probable parents along U.S. Highway 30 south, 3.3 km (2 miles) east of Ft. Bridger, Wyoming. According to him, the hybrid was a low shrub similar in general aspect to Gardner saltbush. However, it has a mass of spinose, unbranched, ascending twigs, and large bracts 8 mm long and 4 mm wide. These features are more like those of shadscale.

Figure 18.--Shadscale saltbush intermixed with perennial grasses and Sarcobatus vermiculatus) *on west side of Sanpete Valley, Sanpete County, Utah.*

Filled utricles have been produced artificially when shadscale pollen was used to fertilize pistillate plants of fourwing saltbush. Of the seeds produced by this procedure, 7.9 percent were viable (table 1). We hope to produce fertile hybrids between these two species.

Plummer and others (1957) reported a number of natural hybrids between shadscale saltbush and cuneate saltbush in the Colorado River drainage 16 km (10 miles) south of Emery, Utah, on Utah Highway 10. Apparently, this is a fairly common hybrid in nature and should not be difficult to produce artificially.

H. C. Stutz and C. L. Pope (personal communication) of the Botany and Range Science Department of Brigham Young University have recently found shadscale occurs as a polyploid series from diploid ($2n$ = 18) to decaploid ($2n$ = 90).

Distribution and habitat: Shadscale occurs most often on heavier soils, although it has been found on soil containing as much as 70 percent sand. Soluble salts in these soils vary from 160 to 3,000 p/m and pH from 7.4 to 10.3 (Hanson 1962).

Shadscale is the dominant plant on over 129,000 km^2 (50,000 mi^2) from Canada to Mexico at elevations from 460 to 2,135 meters (1,500 to 7,000 feet) (Hanson 1962; Branson 1966). It can be found in nearly pure stands on alkaline soils in the Great Basin and other parts of the West (Benson and Darrow 1944). Over much of its range, shadscale occurs in mixed stands with species of greasewood (*Sarcobatus*) (fig. 18), sagebrush (*Artemisia*), hopsage (*Grayia*), rabbitbrush (*Chrysothamnus*), horsebrush (*Tetradymia*), and juniper (*Juniperus*). It endures highly alkaline soils better than most of these associates and can be found growing with such halophytes as glasswort (*Salicornia*) (Hall and Clements 1923). Bud sagebrush (*Artemisia spinescens*) is a

frequent codominant or subdominant species with shadscale in areas where they occur together. Numerous ecotypes of shadscale enable it to grow over a wide range of sites.

Use: Shadscale, in contrast to fourwing saltbush, becomes rigid and spiny as it matures, and during the winter some forms become nearly leafless. However, persistence of leaves varies greatly among areas of occurrence. The spiny characteristic saves this species from heavier grazing than it would otherwise receive and is believed to be a factor in its survival. Shadscale, nevertheless, is palatable to all classes of livestock; the seeds are the most preferred and nutritious part of the plant (U.S. Forest Service 1937). According to Sampson and Jespersen (1963), as the leaves and fruits drop in the autumn, they often accumulate around the parent shrubs. Livestock readily seek this accumulation. Sampson and Jespersen (1963) gave shadscale a browse rating of good to fair for sheep, goats, and deer; fair for cattle; and poor to useless for horses. Hutchings (1952) recorded heavy local damage to productive shadscale range by a snout moth (Pyralidae). The moth damage cleared the way for invasion of noxious halogeton (*Halogeton glomeratus*).

Since shadscale is generally more salt tolerant than fourwing, it apparently could be used for restoration of and soil stabilization on salt-bearing ranges. However, most trials have shown the species to be difficult to establish from direct seeding. It does establish well from transplanting in the early spring when soil moisture remains high for at least 6 weeks. Paradoxically, over a period of years, it shows good natural reproduction. Evidently, a seed source builds up in the ground to sprout and become established during favorable springs.

Atriplex corrugata (mat saltbush)

Mat saltbush is a low shrub that forms dense, extremely prostrate, nearly white mats 5 to 20 times wider than they are high (fig. 19). The prostrate branches often produce adventitious roots where they contact the soil. The bark is soft, spongy, and white.

Figure 19.--Mat saltbush (Atriplex corrugata) *growing on heavy saline soil (mancos shale) in Emery County, Utah.*

Figure 20.--Mat saltbush and Castle Valley clover saltbush growing on outcropping of Mancos shale in a juniper-pinyon-grass type in northeastern Sevier County, Utah.

The evergreen sessile leaves are opposite on the lower parts of the stems and alternate above. The blades are densely scurfy and measure 7 to 18 mm wide.

Bushes are dioecious or rarely monoecious. The yellow to light-brown staminate flowers are borne in glomerules 3 to 6 mm wide on nearly naked spikes. The pairs of fruiting bracts that enclose the pistils of the female flowers are sessile or subsessile, 3 to 5 mm long, 4 to 6 mm wide, united along seven-tenths of their length and usually densely tuberculate on the lower one-third (fig. 7).

Mat saltbush flowers from April to June and the fruit ripens 5 to 6 weeks later. There are about 100,900 cleaned utricles of mat saltbush per pound (223/g).

Hybridization: Viable seed has been obtained by artificially pollinating fourwing saltbush with pollen from mat saltbush (table 1). Natural hybrids between this species and *A. gardneri* and *A. confertifolia* have been found (Hanson 1962). Mat saltbush is tetraploid ($2n = 36$) (H. C. Stutz and C. L. Pope, personal communication).

Distribution and habitat: Mat saltbush is distributed mainly on soils derived from the Mancos Shale Formation in eastern Utah (fig. 20), western Colorado, and northwestern New Mexico at elevations from 1,220 to 2,130 meters (4,000 to 7,000 feet). It tolerates up to 13,000 p/m soluble salts and is often the only perennial plant present where such high concentrations of salt occur (Hanson 1962). Mat saltbush is probably the most halophytic shrub in the genus, but it is frequently found in areas where the salt concentration is not so high. In these areas, it may be associated with shrubs such as winterfat, cuneate saltbush, shadscale saltbush, fourwing saltbush, black greasewood, bud sagebrush, and gray molly (*Kochia americana* subsp. *vestita*). We have successfully transplanted young plants into a former greasewood type in the Great Basin.

Use: Mat saltbush is grazed by sheep, particularly in summer and fall after other forage has been used or has dried up. Poisoning may result when little else is eaten (Hall and Clements 1923). This species has some potential for use in range restoration and soil stabilization projects, particularly in the more saline-alkaline areas of the West (McArthur and others 1974).

Atriplex cuneata (Castle Valley clover saltbush)

Castle Valley clover saltbush is a low shrub with a more or less prostrate, woody, much-branched base and erect branches (fig. 21). The light gray-green, spatulate to broadly elliptic evergreen leaves are 2 to 6 cm long and 0.5 to 2.5 cm wide (Hall and Clements 1923).

This species is usually dioecious. Its yellow to brown staminate flowers are borne in glomerules arranged in panicles. The pistillate flowers are borne in axillary clusters and consist of pistils enclosed by wingless bracts. At maturity, the bracts are 5 to 9 mm wide, irregularly toothed along their margins, and have numerous, flattened, crestlike tubercles on their sides (fig. 7 and 22).

Blooming occurs from mid-April to July, depending on elevation and on climatic conditions. Ripening of the fruit follows about 7 weeks later (Hanson 1962). There are about 81,660 cleaned, hammer-milled utricles of *A. cuneata* per pound (180/g).

Hybridization: Hanson (1962) reported that *A. cuneata* is a highly variable species that hybridizes with every perennial *Atriplex* it is sympatric with except *A. obovata*. Included are *A. canescens* (fig. 10), *A. confertifolia* (fig. 17), *A. corrugata*, *A. garrettii*, *A. tridentata*, and *A. welshii*. *Atriplex cuneata* has both diploid ($2n = 18$) and tetraploid ($2n = 36$) populations (H. C. Stutz and C. L. Pope, personal communication).

*Figure 21.--Castle Valley clover saltbush (*Atriplex cuneata*) from Emery County, Utah.*

Figure 22.--Plantation in Castle Valley, Utah, shows saltbush planting heavily browsed in winter.

Distribution and habitat: *Atriplex cuneata* occurs in highly alkaline soils in eastern Utah, southwestern Colorado, and northern New Mexico. In these areas, the species is often the dominant plant (fig. 23) or is codominant with *A. confertifolia* and *A. corrugata* (fig. 20).

Use: Castle Valley clover saltbush remains green and succulent throughout the winter and is highly palatable to all grazing animals. It is thus an important forage shrub in the highly alkaline areas where it occurs.

This shrub shows promise for use in artificial restoration of certain game winter ranges with highly saline-alkaline soil (McArthur and others 1974).

Atriplex gardneri (Gardner saltbush)

Gardner saltbush is a low subshrub. The lower one-fourth to three-fourths of the plant is slightly woody and the rest is herbaceous (fig. 24). Its habit varies from decumbent creeping forms to rounded forms 3 to 5 times broader than they are high. The spineless decumbent branches usually produce adventitious roots where they contact the soil. These plants also root sprout vigorously (Nord and others 1969). Annual flowering stems arise from the woody portion of the plant.

The lightly scurfy leaves are evergreen, spatulate to oblanceolate to obovate, 15 to 55 mm long, and 5 to 12 mm wide (Hanson 1962).

The majority of plants of this species are dioecious. The brown staminate flowers are borne in glomerules 3 to 5 mm wide on nearly naked one-branched terminal panicles (fig. 25). The pistillate flowers are borne on leafy spikes (fig. 26). Hanson (1962) observed that about 5 percent of the plants he inspected were monoecious.

Figure 23.--Castle Valley clover saltbush as dominant plant on heavy alkaline soil in Emery County, Utah.

*Figure 24.--Gardner saltbush (*Atriplex gardneri*) showing excellent recovery after being burned 3 years before. Note its spreading habit from root sprouts.*

Figure 25.--Staminate Gardner saltbush showing male flower clusters.
Figure 26.--Pistillate Gardner saltbush showing developing utricles.

Fruiting bracts that enclose the female flowers are 3 to 6 mm long, 2.5 to 5.0 mm wide, and are sessile. Their surfaces range from smooth and free of tubercles to densely tuberculate. The apex of the bracts ends in an oval terminal tooth subtended by two slightly smaller lateral teeth (fig. 7).

Gardner saltbush flowers from mid-May to the first of July and intermittently following heavy rains.

The fruit ripens about 7 weeks after flowering. Cleaned utricles average 111,450 per pound (246/g) for this species (Plummer and others 1968).

Gardner saltbush was considered as a subspecies of Nuttall saltbush (*A. nuttallii*) by Hall and Clements (1923) in their classic monograph. They recognized six subspecies of Nuttall saltbush: *typica* (*nuttallii*), *tridentata*, *gardneri*, *cuneata*, *buxifolia*, and *falcata*. They contended that "the first three subspecies form a very close group, and since they occupy the same region, it is questionable if all should not be treated as one." More recently, Hanson (1962, 1973) elevated the subspecies to specific rank. The taxonomy of this group remains somewhat confused. The species *tridentata* and *gardneri* are similar morphologically, but the former is usually hexaploid ($2n = 54$) and the latter tetraploid ($2n = 36$) (Bassett and Crompton 1971; H. C. Stutz and C. L. Pope, personal communication). *Atriplex tridentata* has been described as a subspecies of *A. gardneri* (Holmgren and Reveal 1966). We classify questionable collection as *A. gardneri*.

Nuttall saltbush (*A. nuttallii*), which is widespread in Wyoming, Montana, and Idaho, but only sparsely present in Utah, resembles Gardner saltbush in most characteristics. However, it root sprouts less vigorously than Gardner saltbush and it has the ability to aggressively stem layer (Nord and others 1969).

Hybridization: Fifty percent of the branches of pistillate fourwing saltbushes treated with Gardner saltbush pollen produced viable seed. This percentage was higher than that for any other treatment except *A. canescens* crossed with *A. canescens* where four out of five branches (80 percent) produced viable seed (table 1). Natural hybridization between Gardner saltbush and *A. confertifolia* also occurs. Gardner saltbush is tetraploid ($2n = 36$) (H. C. Stutz and C. L. Pope, personal communication).

Distribution and habitat: Gardner saltbush is much more restricted in its habitat than fourwing saltbush and shadscale. It is most abundant on nearly bare badland clay soils, which contain to 5,500 p/m soluble salts (fig. 27) (Hanson 1962). It occurs in Wyoming, Colorado, Utah, and southern Idaho.

Use: Gardner saltbush is important as cover on arid sites and as browse for big game and livestock. It is being tested with an assortment of fire resistant shrubs for use in reducing fire hazard in southern California. Such shrubs are being used to replace the highly flammable, high-volume chaparral plants presently there (Nord and others 1969).

Atriplex obovata (broadscale saltbush)

Broadscale saltbush is a subshrub to 8 dm in height with a woody, spreading base that produces numerous ascending to erect branches (fig. 28). The silvery, scurfy, deciduous leaves are elliptical to obovate, 1 to 3.5 cm long, 1 to 2 cm wide, with a short petiole.

This species has yellow staminate flowers borne in small glomerules and arranged 500 to 5,000 to a panicle. The fruiting bracts are broadly cuneate or obovate, 4 to 5 mm long, 5 to 9 mm broad, with smooth or sometimes slightly tubercled surfaces (fig. 7).

Figure 87.--Torrey saltbush growing in western Sanpete Valley, Sanpete County, Utah.

Figure 88.--Broadscale saltbush (Atriplex obovata) growing in the Hamblin Wash drainage west of Tuba City, Coconino County, Arizona.

Broadscale saltbush flowers during July and the fruit ripens approximately 7 weeks later (Hanson 1962). This shrub produces an average of 207,630 cleaned utricles per pound (458/g).

Hybridization: Hanson (1962) reported there are no definitely known hybrids between *A. obovata* and other species; however, *Atriplex* specimens intermediate between *A. acanthocarpa* and *A. obovata* have been reported from Arizona (Kearney and Peebles 1960). H. C. Stutz and C. L. Pope (personal communication) have discovered both diploid ($2n$ = 18) and tetraploid ($2n$ = 36) *A. obovata*.

Distribution and habitat: Broadscale saltbush ranges from southeastern Utah, eastern Arizona, through western New Mexico and western Texas, to northern Mexico. The largest individual plants of this species are found in the more sandy localities. Broadscale saltbush tolerates salinity from 165 to 4,900 p/m soluble salts (Hanson 1962). It is commonly associated with such halophytes as black greasewood, seepweed (*Suaeda*), and alkali sacaton (*Sporobolus airoides*).

Use: Broadscale saltbush is an important browse plant in alkaline areas. It makes rapid growth and is most succulent in the spring. Within areas of adaptation, this species should be useful for stabilizing disturbed sites. It has been observed to invade the disturbed margins of newly constructed highways.

Ceratoides lanata (winterfat)

Winterfat's longstanding scientific binomial, *Eurotia lanata*, has been recently changed by Howell (1971). He proposed the name *Ceratoides lanata*. Winterfat is an erect or spreading subshrub that shows wide variation in stature from dwarf forms less than 40 cm in height to larger forms to 1.5 meters (fig. 29). The dwarf forms are

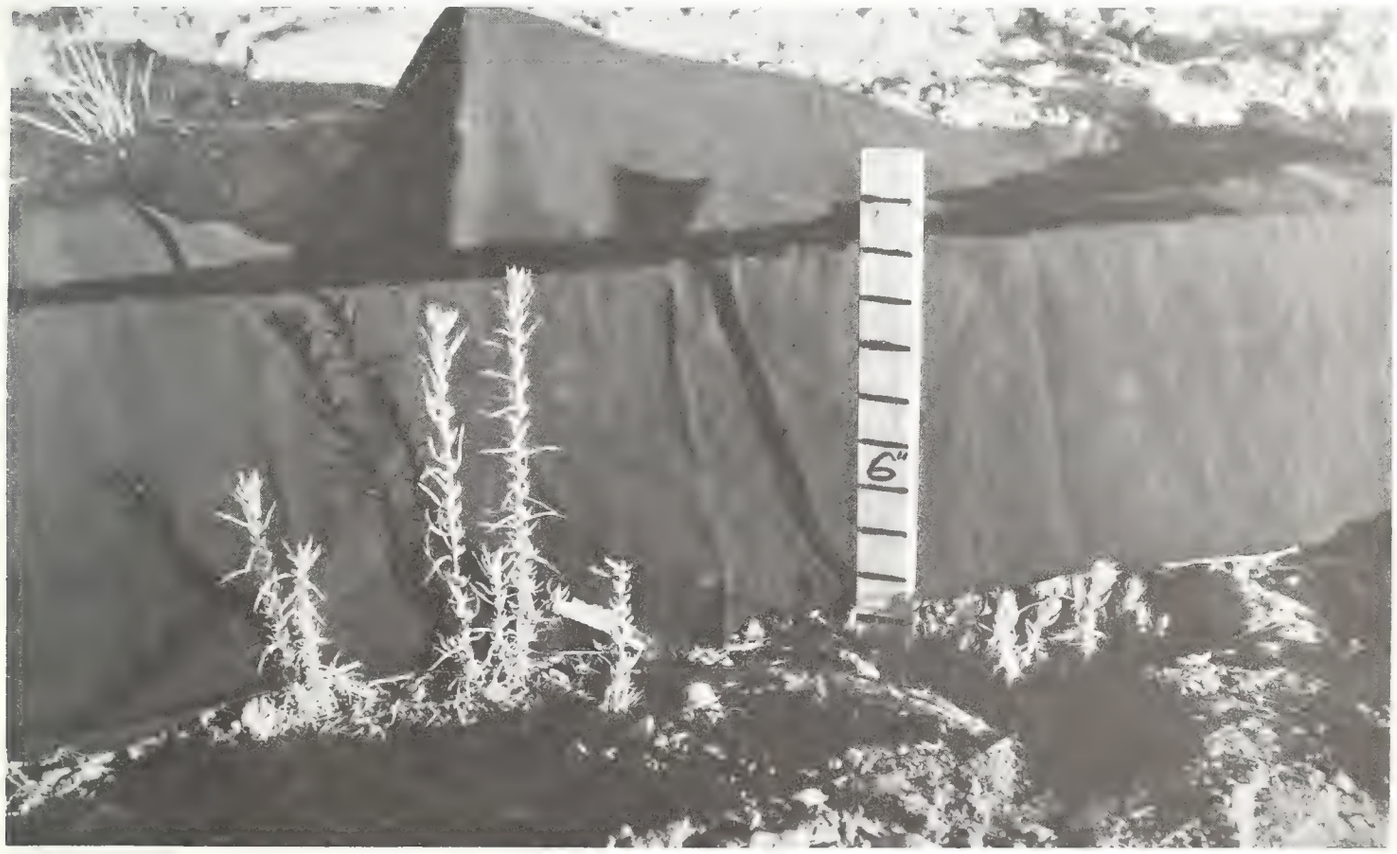

Figure 29.--Tall (left of stake) and dwarf (right of stake) forms of winterfat (Ceratoides lanata) *at end of second season of growth on a site in the juniper-pinyon type, Sanpete County, Utah.*

herbaceous above a woody base. Taller forms tend to be woody throughout (fig. 30). Branches and leaves are covered with a dense coating of stellate and simple hairs that are white when young, but become rust colored with age.

The leaves are alternate, linear, 5 to 50 mm long, with entire, strongly revolute margins.

Winterfat may be either monoecious or dioecious. The flowers are borne in dense paniculate clusters along the upper portion of the branches. The pistillate flowers are below the staminate flowers on monoecious plants.

Staminate flowers lack bracts and petals. They are comprised of four sepals and four stamens borne opposite the sepals.

Pistillate flowers lack both sepals and petals. Pistils are enclosed by a pair of bracts that are united more than half their length. The bracts are covered and often obscured by long, silky hairs (fig. 31). These long hairs distinguish winterfat from species of *Atriplex*.

Site and climate permitting, winterfat blooms between May and August. The fruit ripens from September to November and is dispersed by wind in late fall and winter. Seed production is extremely variable. A scant crop is produced in most years. However, a heavy seed crop can be produced in years of good summer storms coupled with the absence of summer grazing. Such productive crops on dry desert ranges may occur but once in a decade. Cleaned seeds of this shrub average 112,275 per pound (248/g) (Plummer and others 1968).

Figure 30.--Mature tall form of winterfat with good seed production, growing on Shay Mesa, northeast of Monticello, San Juan County, Utah.

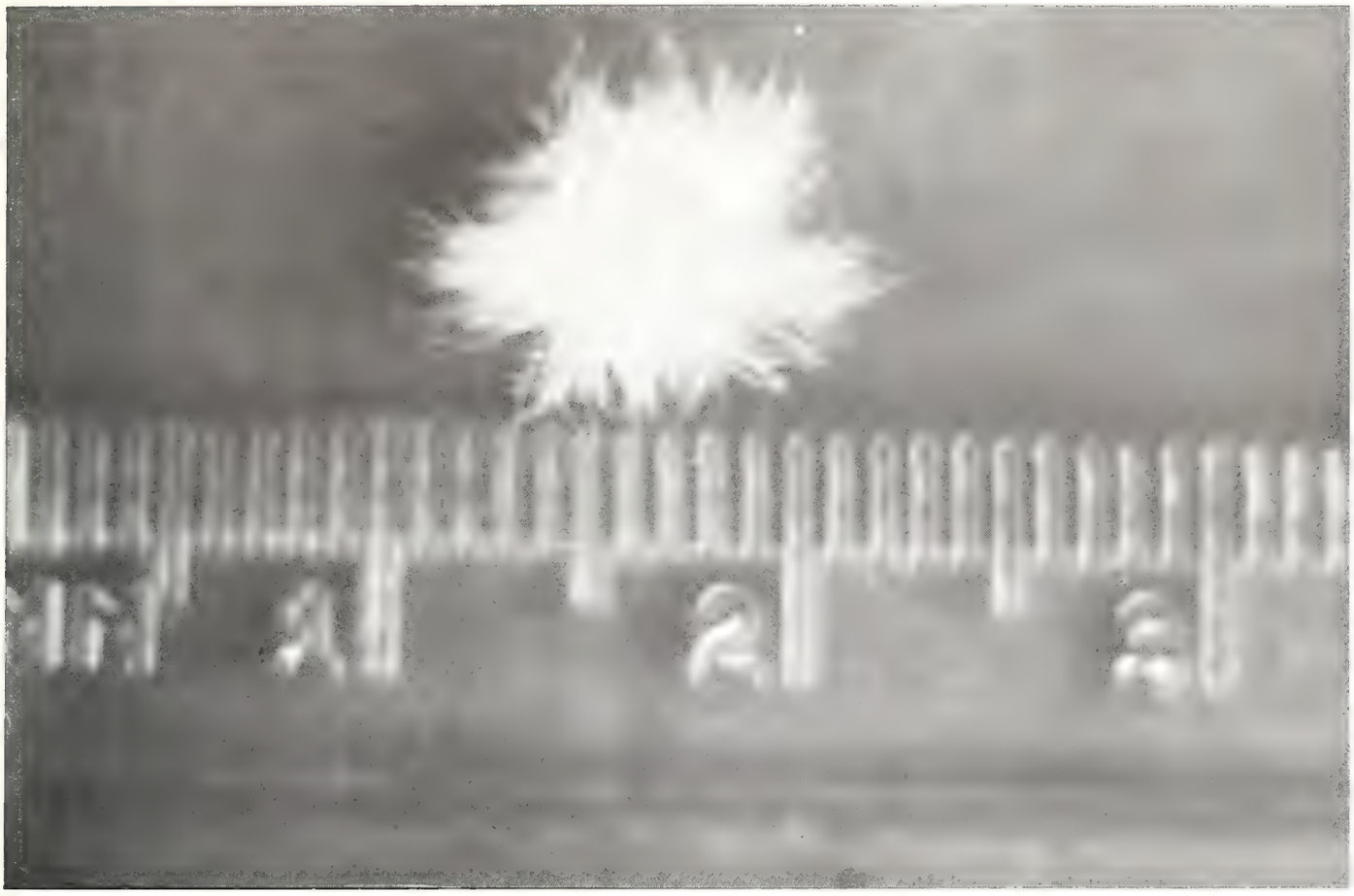

Figure 31.--Winterfat utricle showing dense, long, silky hairs. (Scale in mm.)

Winterfat is remarkably resistant to drought, and even on dry sites will produce seed in the third and fourth year. On favorable sites, plants have produced some seed in their first year of growth. The species has a deep taproot and numerous extensive lateral roots. The plant may appear dead after unusually dry years, but it normally recovers after rain. It exhibits strong reproductive qualities; however, establishment from artificial seeding has often been unsuccessful because seedlings are highly sensitive to frost damage.

Hybridization: The different ecotypes (forms) of winterfat not only show wide variation in stature, but also in seed production, seed size, seedling germination and vigor, pubescence on fruit and seed, and tolerance to varying pH in soils.

A more woody, somewhat spinescent form of winterfat (*C. lanata* ssp. *subspinosa*) occurs on rocky hills in southern Utah, Arizona, California, and Mexico. It apparently is the only form present in southern Arizona. This subspecies shows intergradation in all characteristics with typical winterfat (Kearney and Peebles 1960). Possible production of superior strains through hybridization and selection appears excellent because of the wide variation between ecotypes and the natural hybridization with subspecies *subspinosa*. Riedl and others (1964) found that parts of female plants covered with muslin bags did not set seed, but uncovered parts did; so winterfat appears to be wind pollinated. Thus, one should be able to bag a branch bearing pistillate flower buds for use in hybridization. The desired pollen could be introduced when the flowers are in bloom and the stigmas receptive. A limited number of viable seeds have been obtained by pollinating fourwing saltbush pistillate flowers with winterfat pollen (table 1). None of the seedlings have survived. Winterfat is diploid with a chromosome number of $2n = 18$ (Bassett and Crompton 1971).

Distribution and habitat: Winterfat is most abundant on lower foothills, plains, and valleys with dry subalkaline soils in Utah, Nevada, Arizona, and New Mexico. In the Great Basin, it often occurs in pure stands over thousands of hectares (Benson and Darrow 1944), and is an important component over millions of hectares of the salt desert shrub type (fig. 32). Winterfat ranges from Canada through the Great Basin and Rocky Mountain States to Mexico, and from California and Washington eastward to Texas and North Dakota (Branson 1966). It also grows over a wide range of altitudes. In Utah, it occurs from the lower Sonoran zone to the Alpine ridges. Dwarf forms usually occur on desert floors, on areas of high salt concentration, and on high mountain tops. The larger forms occur on alluvial fans, foothills, and mesas on ponderosa pine and juniper-pinyon sites.

Use: Winterfat is a superior nutritious winter browse for livestock and big game. Sheep, cattle, antelope, elk, deer, and even rabbits utilize it (fig. 33). Except for the woody base and larger stems, the plant is edible. Overgrazing has greatly reduced and even eliminated winterfat on some areas, even though it is relatively tolerant to grazing. Winterfat is potentially one of the most useful shrubs for planting to increase cover and forage on alkaline soils of desert ranges in Utah and adjacent States where the average annual precipitation is less than 25 cm (10 inches). Sampson and Jespersen (1963) give winterfat a browse rating of excellent to good for cattle and sheep; excellent to fair for goats; good to fair for deer; and fair for horses.

The species is a good natural increaser and should be highly useful for stabilization in areas where it naturally occurs. Good stands have resulted from broadcasting utricles on such areas.

Figure 32.--Pure stand of winterfat on a fine silty soil at Desert Range Experiment Station, Millard County, Utah.

Figure 33.--Sheep grazing on winterfat-shadscale saltbush in Pine Valley, Millard County, Utah.

Grayia—Common Floral Characteristics

Grayia, like *Atriplex*, has staminate flowers of four or five sepals, four or five stamens, and pistillate flowers that lack both sepals and petals but have pistils enclosed by pairs of bracts. The margins of each pair of bracts are united from base to apex except for a minute apical opening. Collotzi (1966) on the basis of a morphological, embryological, and chromatographic study recommended that *Grayia* be reclassified as *Atriplex*. From our observations, we believe this would be appropriate; but, because of the long past usage, we suggest that the present nomenclature remain unchanged.

Grayia brandegei (spineless hopsage)

Spineless hopsage is a subshrub to 1 meter tall (fig. 34) with linear-oblanceolate to obovate leaf blades 1.5 to 4.5 cm long (Collotzi 1966).

The flowering period varies between mid-June and mid-August. Seed matures in late September through early October. Utricles (fig. 35) persist on the plants until January and some may last through the winter. These are often removed by small mammals and birds. Cleaned seeds of *Grayia brandegei* average 189,950 per pound (419/g)(Plummer and others 1968).

Hybridization: Drobnick and Plummer (1966) reported occurrence of natural hybrids of spineless hopsage with shadscale saltbush and cuneate saltbush. Viable seeds have been obtained by artificially pollinating fourwing saltbush pistillate flowers with pollen from spineless hopsage. This cross of all those attempted on fourwing saltbush yielded the highest percentage of viable seed; however, of the eight branches treated,

Figure 34.--Large spineless hopsage growing in foothills in northwestern Antelope Valley, Sanpete County, Utah.

Figure 35.--Pistillate spineless hopsage with developing utricles.

Figure 36.--Spineless hopsage population in northwestern Antelope Valley, Sanpete County, Utah.

only one produced viable seed (table 1). Unfortunately, none of the resultant seedlings survived. These progeny are essential for verifying the nature of the purported crosses. We are confident that our continuing hybridization work, associated with better care of any resultant seedlings, will yield the needed progeny. Spineless hopsage is tetraploid with a chromosome number of $2n = 36$ (C. L. Pope and E. D. McArthur, data on file at Shrub Sciences Laboratory, Provo, Utah).

Distribution and habitat: Spineless hopsage is generally restricted to shale formations of the Upper Colorado River Drainage. It favors silty clay loam soil derived from shales. Collotzi (1966) noted it occurred under mildly alkaline (pH 7.4 to 7.7) conditions. Other populations occur on similar soils in central Utah (fig. 36) and in southeastern Colorado.

Use: This species may be used as browse by livestock and big game. It germinates and produces seedlings readily; but, unless protected, these are quickly taken by rodents and rabbits. These small mammals have shown a high preference for the seedlings established at several locations. Kingsbury (1964) lists spineless hopsage as a possible secondary or facultative selenium absorber. As such, it could be mildly poisonous in areas where the soil contains selenium.

Grayia spinosa (spiny hopsage)

Spiny hopsage is an erect, diffusely branched, spinescent shrub from 3 to 12 dm in height (fig. 37). It differs in many respects from spineless hopsage, but both species have similar utricles (fig. 7, 35, 38).

*Figure 37.--Spiny hopsage (*Grayia spinosa*) growing on a restricted type of heavy, white calcareous soil on top of foothills south of Ephraim, Sanpete County, Utah.*

Figure 38.--Closeup of spiny hopsage showing developing utricles on branch tips and the fleshy, oblanceolate leaves.

The deciduous leaves are oblanceolate, 0.4 to 4.3 cm long, 2 to 13 mm wide, and somewhat fleshy (fig. 38).

The small, greenish unisexual flowers usually occur on separate plants, but in some populations as many as 5 percent of the shrubs are monoecious. The staminate flowers are clustered in glomerules in the axils of leaves, whereas the pistillate flowers are mostly in dense terminal spikes.

The fruits are enclosed by pairs of conspicuous, rounded or obovate, flat-winged, sessile bracts, 5 to 12 mm wide, and often tinged with red (fig. 7) (McMinn 1939).

The flowering period of spiny hopsage is from April to June. On a site in central Utah, south of Ephraim, at an elevation of 1,830 meters (6,000 feet), seeds matured from June 15 to July 17 over a 5-year period. In most places, the seeds tend to be mature and disseminating before July 15. Shortly after seed maturity, the leaves ordinarily fall, but there is wide variation in this characteristic. An unusual form in Daggett County, northeastern Utah, has some leaves remaining on the shrub throughout the following season. Cleaned seeds (seeds removed from the utricles) of this shrub average 166,765 per pound (368/g) (Plummer and others 1968).

Hybridization: Hybrids between fourwing saltbush and spiny hopsage have been obtained by treating pistillate flowers of fourwing saltbush with pollen from spiny hopsage (Drobnick and Plummer 1966). Spiny hopsage has a chromosome number of $2n = 36$ (C. L. Pope and E. D. McArthur, data on file at the Shrub Sciences Laboratory, Provo, Utah).

Distribution and Habitat: Spiny hopsage is found over a wide range of soils on plains and foothills in California northward to eastern Oregon and Washington, and east to New Mexico, Colorado, and Wyoming. Soils are typically high in calcium and strongly basic but, in some areas, they are essentially neutral. On extensive tracts, spiny hopsage occurs with big sagebrush. It is somewhat fire tolerant, often surviving fires that kill sagebrush.

Use: Spiny hopsage is a valuable forage plant in areas where it is abundant, particularly in the spring when it is in full leaf. This is the time when livestock and game seek it out. This species was given a browse rating by Sampson and Jespersen (1963) of good to fair for sheep, goats, and deer; fair to poor for cattle; and poor to useless for horses.

Kochia americana subsp. *vestita* (gray molly summer cypress)

Gray molly summer cypress is a small, woody-based subshrub to 5 dm tall (fig. 39). Its numerous, annual, erect branches and leaves are covered with long, silky hairs. The linear, fleshy, more or less terete leaves are 5 to 30 mm long. Hairy perfect or pistillate flowers are borne singly or in small clusters in the axils of leaves along almost the full length of the branches. At anthesis, the hooded calyx lobes are about 1.5 mm long and closely cover the ovary. At maturity, the fruit is largely concealed in the persistent calyx, which develops conspicuous, horizontal, fanlike papery wings to 3 mm long. This species blooms from June to August. It produces about 257,200 cleaned seeds per pound (566/g).

Hybridization: Natural hybrids between *Kochia americana* and other native species are unknown. Perhaps improvement of this species by hybridization with introduced species such as *Kochia prostrata* will prove feasible. This is yet to be tested. The chromosome number of gray molly is unknown.

Figure 39.--Gray molly summer appress (Kochia americana subsp. vestita) habit.

Distribution and Habitat: Gray molly usually occurs in saline or alkaline clay soil on plains and foothills between 1,370 to 1,830 meters (4,500 to 6,000 feet). Its range extends from southern Montana west to Oregon and south to New Mexico, Arizona and California.

Use: Kochia americana is quite widely used as winter forage by sheep when it is sufficiently abundant (Kearney and Peebles 1960). Sampson and Jespersen (1963) gave this species a browse rating of fair to poor for sheep and goats; poor to useless for deer; and useless for cattle and horses. In Utah, we have observed that *K. americana* ssp. *vestita* may be closely grazed by sheep and cattle on winter ranges.

Gray molly appears to have usefulness in revegetation of areas with a high salt concentration, particularly spent coal and oil shales. Trials are warranted on these kinds of sites but, as far as is known, have not been carried out.

Kochia prostrata (prostrate kochia)

Prostrate kochia is generally a long-lived, highly variable, woody-based subshrub. However, some ecotypes may be definite upright shrubs. It ranges from less than 0.3 meter to over 1 meter in height (fig. 40). Ascending branches are covered with short to long woolly hairs. Leaves are flat, linear to filiform, and hairy. Flowers are borne in small clusters (glomerules) in the axils of slightly reduced leaves on the upper part of the stem. The perianth consists of a hairy, persistent calyx. As the fruit develops, the calyx forms dorsal appendages around it that are rounded, flat and tuberclelike, or oblong and winglike (Shishkin 1936). Blooming occurs from July to September. Seeds of prostrate kochia number approximately 500,000 per pound (1,102/g) (Keller and Bleak 1974).

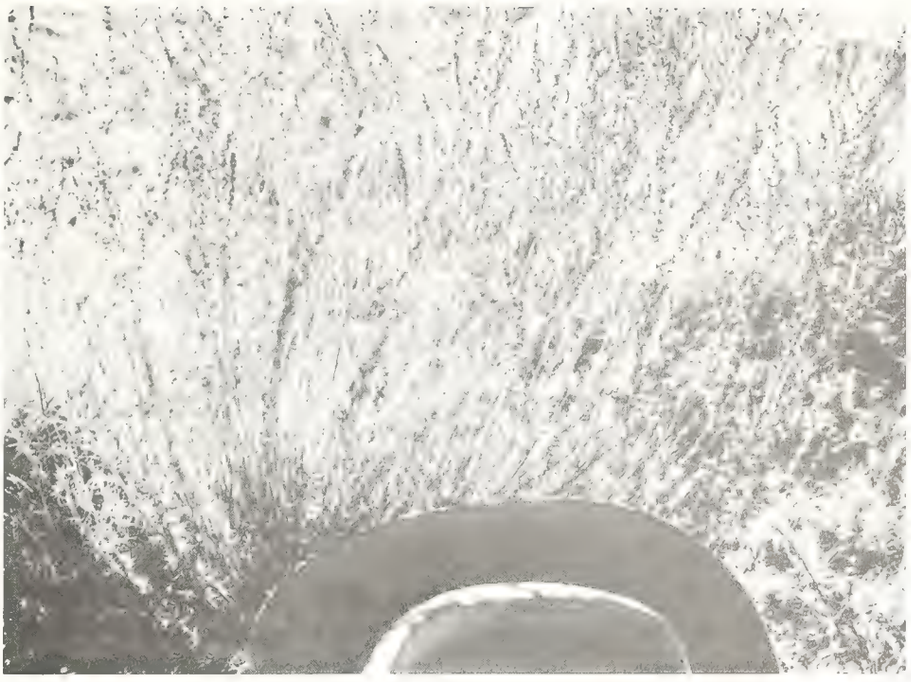

*Figure 40.--Three-year-old prostrate kochia (*Kochia prostrata*) transplanted as seedling to a revegetated range southeast of Ephraim, Sanpete County, Utah. This plant began producing seed the first year as is common for this species. (The hat shows the relative size of the plant.)*

Hybridization: Prostrate kochia is highly polymorphic and consists of numerous geographic races and ecotypes (Shishkin 1936). We foresee great opportunity for selection and development of superior strains for forage and cover. *Kochia prostrata* is diploid, $2n$ = ca.18 (C.L. Pope and E. D. McArthur, data on file, Shrub Sciences Laboratory, Provo, Utah).

Distribution and Habitat: Prostrate kochia is native to arid and semiarid regions of central Eurasia where it grows on alkaline, stony, and sandy steppes and plains (Shishkin 1936). Seed of several ecotypes were introduced into the United States during the 1960's. This species appears to adapt well to the climate and soils of the Intermountain area (Keller and Bleak 1974). It establishes readily from transplants (fig. 40) and seed (fig. 41).

Figure 41.--Rows of prostrate kochia planted for seed increase at the Snow Field Station, Sanpete County, Utah. Note the volunteer reproduction between rows.

Use: Prostrate kochia shows considerable potential for becoming a valuable forage and cover plant on our arid western ranges. In its native habitat, it is a drought-resistant, salt-tolerant species and is highly valued as a forage plant. Sheep, goats, camels, and horses all use it (Shishkin 1936). Our preliminary observations in Utah indicate that this species is sought out by mule deer. Kochia readily establishes from seed, grows rapidly and, under favorable conditions, reaches sexual maturity in 1 year (McArthur and others 1974). Once established, it is a good natural spreader.

Sarcobatus vermiculatus (black greasewood)

Black greasewood is an erect, spiny-branched shrub to 3 m tall (fig. 42). Its numerous rigid branches become gray with age. The deciduous, bright-green leaves are 1 to 4 cm long, narrowly linear, and semiterete.

This shrub is usually monoecious with staminate flowers borne in catkinlike spikes 0.5 to 3 cm long. These flowers lack both sepals and petals and consist only of two to three stamens borne under closely packed, long-stalked, shieldlike bracts. The pistillate flowers are borne below the staminate catkin in the axils of reduced leaf-like bracts. These flowers have a closely compressed calyx barely 1 mm long at anthesis, which greatly enlarges in fruit. The flowers bloom from May to July.

The pistils are enclosed by cuplike perianths. The lower portion of each perianth becomes adherent to the ovary and the upper portion expands into a broad, membranous, horizontal wing, 6 to 13 mm wide, in the fruit (fig. 7). Cleaned seeds of this species average approximately 285,600 (630/g) cleaned seed per pound.

Hybridization: Drobnick and Plummer (1966) reported a small population of putative hybrid derivatives of fourwing saltbush and black greasewood growing among parental species on the east side of the Lakeside Mountains north of Delle, Tooele County, Utah.

*Figure 42.--Black greasewood (*Sarcobatus vermiculatus*) growing near Tuba City, Coconino County, Arizona.*

Drobnick and Plummer (1966) have also obtained viable seed by treating fourwing saltbush pistillate flowers with black greasewood pollen. Some of the resultant progeny have been planted in a test plot near Manti, Utah. In our tests, 1 out of 10 pistillate fourwing saltbush branches produced viable seed when cross-pollinated with black greasewood (table 1). Additional studies are needed to verify the true nature of these putative hybrids. Bassett and Crompton (1970) report black greasewood to be tetraploid with a chromosome number $n = 18$. Stutz and Pope (personal communication) have discovered both tetraploid ($2n = 36$) and octoploid ($2n = 72$) populations of black greasewood.

Distribution and Habitat: Black greasewood grows on a wide range of soils, but is most characteristic on rather heavy, alkaline soils where flood waters collect or on soil that have a high water table at least part of the year. Salts accumulate in such areas. Thus greasewood is usually associated with soils of high salt (alkali carbonates, or "black alkali") content (Shantz and Piemeisel 1940; Kearney and Peebles 1960).

Black greasewood is found at low and middle elevations from Alberta, Canada, south to Texas and California, and from the Dakotas, Colorado, and New Mexico west to Washington, Oregon, and California (Dayton 1931). A smaller species of greasewood, *S. baileyi*, occurs on desert hillsides and plains in association with shadscale saltbush, winterfat, and other salt desert shrubs in eastern California and western Nevada. This shrub seldom occurs in pure stands as does *S. vermiculatus*.

Black greasewood can be found in nearly pure stands in the more saline areas of its range. In less saline areas, it may be found growing with such shrubs as shadscale saltbush, Gardner saltbush, green rubber rabbitbrush (*Chrysothamnus nauseosus* ssp. *consimilus*), whiteflower, or alkali rabbitbrush (*C. albidus*), basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) (fig. 43), bud sagebrush (*A. spinescens*), spiny hopsage (*Grayia spinosa*), and winterfat (*Ceratoides lanata*).

Figure 43.--A mixed population of black greasewood and basin big sagebrush north of Ephraim, Sanpete County, Utah.

Use: Black greasewood is used as browse by cattle and sheep. These animals eat the young shoots and leaves in winter and spring (Kearney and Peebles 1960). According to Kingsbury (1964), "greasewood is considered useful forage by most ranchers, and many large areas of range would be worthless for raising animals if it were absent."

Black greasewood was given a browse rating of fair to poor for sheep and goats; poor for deer; fair to useless for cattle; and useless for horses by Sampson and Jespersen 1963).

Unfortunately, black greasewood contains soluble oxalates, which may cause poisoning and death if hungry animals consume a large amount of greasewood in a short time. This can be prevented by providing other forage in the diet or at least by spreading out the consumption of greasewood over a period of several hours or more (Kingsbury 1964). In its distribution range, it shows marked ability to naturally establish on disturbed areas, such as roadsides.

APPENDIX

CHENOPODIACEAE—Key to Genera and Species

(Nomenclature follows Plummer and others 1966b and Howell 1971).

1a. Flowers perfect or polygamous.....*Kochia*

2a. Branches erect, not more than 0.5 meter high; leaves fleshy, linear, more or less terete...*K. americana* subsp. *vestita*

2b. Branches ascending, up to 1.2 meter high; leaves not particularly fleshy, linear to filiform, flat.....*K. prostrata*

1b. Flowers imperfect, monoecious or dioecious.

3a. Shrubs spinescent; leaves narrowly linear, semiterete; staminate flowers without perianth, borne in catkinlike spikes; fruit with a horizontal wing.....*Sarcobatus vermiculatus*

3b. Shrubs or subshrubs, not spinescent, or if spinescent, then leaves different from above; staminate flowers with perianth, not borne in catkinlike spikes; fruits not with horizontal wings.

4a. Bracts of fruit with many long hairs that form the conspicuous feature of the inflorescence; margins of leaves rolled tightly downward (revolute); hairs on branches and leaves stellate...*Ceratoides lanata*

4b. Bracts of fruit glabrous; margins of leaves not revolute; hairs not stellate..5

5a. Margins of fruiting bracts united from base to apex, the apical opening minute; pubescence of simple or branched hairs, rounded axillary buds present.....*Grayia*

6a. Shrubs with spinescent branches; fruiting bracts glabrous, not keeled, usually over 6 mm wide.....*G. spinosa*

6b. Shrubs not spinose; fruiting bracts scurfy, pubescent, keeled at maturity, usually less than 6 mm wide.....*G. brandegei*

5b. Margins of fruiting bracts only partially united or not united at all; pubescence of inflated hairs or lacking; rounded axillary buds lacking.....*Atriplex*

7a. Fruiting bracts normally with four lateral wings; shrubs to 2 meters or occasionally more high.....*A. canescens*

7b. Fruiting bracts without lateral wings; spinose shrubs or subshrubs normally less than 2 meters high.

8a. Shrub spinose; staminate flowers yellow; fruiting bracts foliose, united only at the base, with smooth surfaces and entire or nearly entire margins....*A. confertifolia*

8b. Subshrubs, weakly or not spinose; staminate flowers yellow or brown; fruiting bracts not foliose, at least one-third united, with surface frequently appendaged or margins toothed, sometimes both.....9

9a. Plants ascending to erect; leaves obovate or broadly elliptic; lower leaves alternate; fruiting bracts broader than long, with truncate, dentate apex and usually smooth sides.....*A. obovata*

9b. Plants more or less prostrate; lower leaves opposite or subopposite; leaves usually narrower than those of *A. obovata*; fruiting bracts longer than broad, with sides usually appendaged.

10a. Plants prostrate mats under 15 cm; leaves less than 4 mm wide; staminate flower in spikes; fruiting bracts appendaged to the lower one-third.....*A. corrugata*

10b. Plants usually over 15 cm tall; leaves more than 4 mm wide; staminate flowers in panicles; fruiting bracts various.

11a. Fruiting bracts 5 to 9 mm wide, usually heavily tuberculate; leaves light gray-green.....*A. cuneata*

11b. Fruiting bracts 2 to 5 mm wide without tubercles, or if present, these less than 1 mm long; leaves green.....*A. gardneri*

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This paper reviews the state of knowledge, records observations, and presents original data for important Intermountain chenopod shrubs. A key is given to aid recognition of taxa. Each species treated is described and its hybridization, distribution and habitat, and use are reviewed. Results of interspecific and intergeneric hybridization experiments are presented.

OXFORD: 181.1; 165.71.
KEYWORDS: distribution, hybridization, chenopod shrubs, habitat, use, <u>Atriplex</u>, <u>Ceratoides</u>, <u>Grayia</u>, <u>Kochia</u>, <u>Sarcobatus</u>.

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